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Invention: METHOD AND DEVICE FOR CONTACTLESS MEASUREMENT OF A WALL THICKNESS

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Method and device for contactless measurement of a wall thickness

The invention relates to a method for the contactless measurement of the thickness of transparent materials and a device for performing the method. The method is particularly suitable for the wall thickness measurement of container glass.

Devices are already known for the automatic contactless or thickness measurement. (DD 261 832, EP 584673, US 4,902,903, US 3,807,870). These devices employ a laser beam, which is directed onto the object to be measured under a certain angle of incidence.

The laser beam is partially reflected on the front side of the object to be measured. A further part of the beam is refracted into the material, reflected at the backside, and is again refracted at the front side such that two laser beams are reflected back from the object to be measured. The distance of the two back reflected laser beams is a measure for the wall thickness and is correspondingly evaluated. In most cases a line sensor is disposed in the beam direction

of the reflexes as an evaluation device.

It is a disadvantage with these devices that they cannot be employed for the measurement of container glass. The surface of the container glass is not smooth when measured at the dimensions of the laser beam. The sharply bundled, parallel laser beam is randomly deflected at the relative uneven grained surface of the container. The reflexes of the laser beam, which in principle are to be employed for the determination of the wall thickness, thereby are frequently not reflected back in the direction of the receiving optics. Thus mostly no reflexes are available for the measurement value formation in the controllers.

It is furthermore disadvantageous in connection with these known devices that the wall thickness measurement value is heavily influenced by the non-parallelity of the wall of the measurement object. The two reflected laser beams are propagated only then in parallel, in case the reflecting surfaces of the object to be measured are disposed in parallel. ~~In~~ the reflected surfaces of the object to be measured enclose that wedge angle, then the two reflected beams diverge or converge, whereby the measured value can be

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falsified to such an extent that it becomes useless.

A further erroneous influence is associated with the tipping between the measurement device and the measured object. It is not always assured in particular with measurements in connection with running production that the object to be measured is exactly positioned. The vertical to the surface at the measurement location can therefore deviate in practical situations by a tipping angle relative to the measurement direction of the measurement device.

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A device has already been proposed to compensate the measurement errors based on wedge shape of the wall and on tipping of the object to be measured (DE 4143186). The device also employs laser beams and is therefore also not in the position to deliver reliably reflexes at uneven surfaces of container glass. Thus the device is similarly not suitable for thickness measurements at container glass.

It is further disadvantageous in connection with the conventional constructions that in case of heavily wedged or curved surfaces and simultaneously a limited aperture of the receiving lens, the reflexes cannot be imaged onto the

sensor. The reflexes are reflected back in the direction located outside of the opening of the receiving optics and the reflexes thereby are not available for forming a measurement value.

It is an object of the present invention to furnish a method and a device for performing the method, which allow to obtain reliably reflexes even at non-ideally smooth surfaces of the measurement object and thereby measurement values, wherein the measurement values are not simultaneously falsified by wedge walls and tippings of the measurement object and which method and device delivers evaluable reflexes on the sensors even in case of heavily curved, wedged walls despite a limited aperture of the receiving optics.

The object is accomplished according to the present invention in that the light is initially collimated and then focused onto the surface of the object to be measured under an angle of incidence relative to the vertical or normal of the surface. The two reflexes of the light, that occur at the front side and at the backside are imaged onto an opto-electronic image resolving sensor. At the same time the

light from a second illuminating surface is also initially collimated and in the following focused onto the surface of the object to be measured under an angle of incidence, wherein the angle of incidence corresponds angle of reflection of the reflected beam from the first illuminating surface. The reflexes of the second light beam are imaged onto a second opto-electronic image resolving sensor. The average value of the distances of the respective two reflexes on the opto-electronic image resolving sensors are determined as a measure of the wall thickness in a following controller.

The essence of the invention comprises to image illuminating surfaces onto the surface of the object to be measured. The impingement of the surface of the object to be measured occurs from the most different directions of incidence by employing a diffusely illuminating surface instead of a sharply bundled laser beam. The course of beams out of an illuminating surface, wherein the course of beams is focused on the surface of the container, contains a large bandwidth of light bundles, which impinge onto the container surface from different angles of incidence. This assures that parts of the course of the beams are always reflected back into

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the receiving optics despite the grained, uneven surface of the object to be measured, even though other bundles out of the beam course are not available based on these surface defects. Thus always two reflexes are generated on the opto-electronic image resolving sensor.

Furthermore the measurement errors based on wedge shape and tipping are compensated by a second optical system, which exhibits the identical construction of the first system, however, operates with a reversed beam direction and the imaging of the reflexes onto the sensors is assured based on the widely opened beam bundles even in case of heavily curved surfaces and wedged walls despite limited aperture of the receiving optics.

The advantage of the invention comprises that it allows a reliable measurement at grained, uneven surfaces, that measurement errors based on wedge shape of the wall and tipping of the object to be measured are avoided as that it becomes possible to work with limited apertures of the receiving optics and that thereby size of the measurement arrangements is kept within a justifiable frame. An embodiment example of the invention is shown in the drawing

and is explained in more details in the following.

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The illuminating surface 11, which for example is realized by a line shaped light exit opening of a light guide, is followed by lens 12. This lens generates a parallel beam from the diverging beam exiting from the illuminating surface 11, wherein he parallel beam is directed into the objective 14 through the semi permeable mirror 13. The objective 14 focuses the beam onto the surface of the container 1 under an angle of incidence. Two reflexes are reflected back from the surface of the container 1 from the front side and from the inner side of the container. These two reflexes are imaged through the objective 24 and through the semi permeable mirror 23 and further through the lens 25 onto the line sensors 26. The controller 3 is disposed following to the line sensor 26, wherein the controller 3 determines the distance of the reflexes and uses the distance of the reflexes as a base for the further calculation of the wall thickness.

Sub A7

At the same time the lens 22 is disposed following to the illuminating surface 21, wherein the illuminating surface 21 is again realized by a line shaped light exit opening of a

light guide. Again this lens generates a parallel beam from the diverging beam which exits from the light guide 21, wherein the parallel beam is directed to the semi permeable mirror 23 into the objective 24, wherein the objective 24 also focuses the beams under an angle of incidence onto the surface of the container 1. This angle incidence corresponds to the exit angle of the reflexes from the first illuminating surface 11. Similarly two reflexes derived from the front side and from the inner side of the container are reflected back from the surface of the container 1. These two reflexes are imaged through the objective 14, through the semi permeable mirror 13 and further through the lens 15 onto the line sensor 16. The line sensor 16 is again connected to the controller 3, wherein the controller 3 also determines the distance of these two reflexes and uses the distance of these two reflexes as a base for the further calculation of the wall thickness. The wall thickness is finally determined by an averaging of the distances of the reflexes on the two sensors 16 and 26.

The beams coming from the illuminating faces 11 and 21 are composed of light bundles, wherein the origin of the light bundles lies in each case at different points of the

illuminating surface. The different bundles of the beams therefore have different inclination angles relative to the surface of the object to be measured. Therefore the grained, uneven surface of the object to be measured will deflect only those bundles of the beam from the ideal direction of reflection, which impinge by chance with an unsuitable direction of incidence. In contrast other bundles of the beam are reflected into the direction of the receiving optics despite the surface defects and contribute there to the formation of the two reflexes on the sensors 16 and 26. If a laser beam would be employed for generating the two reflexes at the outside and at the inside, as it corresponds to the state-of-the-art, then one would in most cases obtain no reflexes on the opto electronic receiver, since the narrowly bundled laser beam, which impinges the object to be measured always from the same angle of incidence, is deflected stochastically at the unevennesses of the surface in the majority of cases.

The measurement errors based on wedge shape and tipping are compensated by directing the light from two illuminating surfaces and from opposite directions onto the object to be measured, wherein the exit direction of the first beam

corresponds to the direction of incidence of the second beam.

The construction of the beams employed for measurement from a broad spectrum of differently inclined bundles has finally the consequence that even in case of heavily wedged or curved surfaces and simultaneously a limited aperture of the receiving objective, the two reflexes can always be formed on the sensor. In fact bundles are reflected back from the beams such as that they miss the receiving optics, however, other bundles contribute to an image generation on the sensor, such that it is possible to work also with limited apertures of the receiving optics.